AD 410664

JPRS: 19,251

17 May 1963

OTS: 63-21844

HIGHER WATER PLANTS AS RELATED TO POLLUTED CONTINENTAL BODIES OF WATER

by N. M. Kabanov

- USSR -

U. S. DEPARTMENT OF COMMERCE
OFFICE OF TECHNICAL SERVICES
JOINT PUBLICATIONS RESEARCH SERVICE
Building T-30
Ohio Drive and Independence Avenue, S.W.
Washington 25, D. C.

Price: $.50

F O R E W O R D

This publication was prepared under contract for the Joint Publications Research Service as a translation or foreign-language research service to the various federal government departments.

The contents of this material in no way represent the policies, views or attitudes of the U. S. Government or of the parties to any distribution arrangement.

PROCUREMENT OF JPRS REPORTS

All JPRS reports may be ordered from the Office of Technical Services. Reports published prior to 1 February 1963 can be provided, for the most part, only in photocopy (xerox). Those published after 1 February 1963 will be provided in printed form.

Details on special subscription arrangements for JPRS social science reports will be provided upon request.

No cumulative subject index or catalog of all JPRS reports has been compiled.

All JPRS reports are listed in the Monthly Catalog of U. S. Government Publications, available on subscription at $4.50 per year (6.00 foreign), including an annual index, from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

All JPRS scientific and technical reports are cataloged and subject-indexed in Technical Translations, published semimonthly by the Office of Technical Services, and also available on subscription ($12.00 per year domestic, $16.00 foreign) from the Superintendent of Documents. Semiannual indexes to Technical Translations are available at additional cost.

HIGHER WATER PLANTS AS RELATED TO POLLUTED CONTINENTAL BODIES OF WATER

- USSR -

/Following is the translation of an article by N. M. Kabanov in the Russian-language publication Trudy Vsesoyuznogo Gidrobiologicheskogo Obshchestva (Proceedings of the All-Union Hydrobiological Society), Vol 12, Moscow, 1962, pages 410-415./

(Institute of General and Communal Hygiene imeni A. N. Sysin, Academy of Medical Sciences USSR; Moscow)

Evaluation of the extent of water contamination involves the entire totality of organisms found in the given location of the body of water. However, the higher water and mainly the freshwater plants (higher macrophytes), above all others, can be the focus point in surveys of continental bodies of water. These plants by their size are usually relatively easily accessible to observation. It is not difficult to note any departures from the normal state in these plants.

It is known that land higher plants are used as indicators of various features of the environment and the conditions of their growth. This also can be said of hydrophytes. But to determine the saprobicity of water macrophytes are relatively little used. Of the extensive lists of saprobic indicator-organisms a small number of higher plant species is to be found.

Thus, in the list of saprobicity indicators prepared by G. I. Dolgov and Ya. Ya. Nikitinskiy (1927), only the following pteridophytes and flowering macrophytes are included, not counting the bryophytes. The zone of β-mesosaprobic contains the Elodea canadensis /See Note/, the small duckweed (Lemna minor), the multirooted duckweed (Spirodela polyrrhiza), the dark-green hornwort (Ceratophyllum demersum). The zone of oligosaprobic includes Salvinia natans, the lake quillwort (Isoetes lacustris), the fennel-leaved pondweed, and the curly-leaved pondweed (Potamogeton pectinatus and P. crispus), which are also β-mesosaprobes, shiny pondweed, and the streaked-leaved pondweed (Potamogeton lucens and P. perfoliatus), which sometimes are β-mesosaprobes,

the floating pondweed (Potamogeton natans), found both in the β-mesosaprobic and even in the α-mesosaprobic zones, the star duckweed (Lemna trisulca), filaceous buttercup (Ranunculus confervoides), the spreading buttercup (R. divaricatus), the yellow pond-lily (Nuphar luteum), the white water lily (Nymphaea alba), the spring water chickweed (Callitriche verna), as well as the star duckweed are mainly found in this zone.

([NOTE] Subsequently in the text repeated occurrences of a species will be given only by its Russian name.)

In a list appended to the study of V. I. Zhadin and A. G. Rodina (1950) are included these same plants, with the exception of the floating pondweed, and the filaceous buttercup.

Kol'kvits (Kolkwitz) (1935), one of the founders of the system of saprobicity, presents the following species. The zone of β-mesosaprobic includes Salvinia natens, also o, Elodea canadensis, if developed luxuriantly, the fennel-leaved pondweed, and the curly-leaved pondweed, the streaked-leaved pondweed, also o, the star duckweed, the multirooted duckweed, and the star duckweed, the pond-lily, the water lily, the dark-green hornwort luxuriantly developed, and the polymorphous chickweed (Callitriche polymorphia). The zone of oligosaprobic includes the lake quillwort, the polygonofoliate pondweed (Potamogeton polygonifolius), the autumn chickweed (Callitriche autumnalis), and also βm, Hydrilla verticillata, and also βm, the bushy pondweed (Najas flexilis).

Libman (Liebmann) (1951), in his revised system of saprobicity, listing three representatives of the bryophytes among the dominant hydrobionts, pointed to no pteridophytes and flowering plants at all, although he noted in the composition of typical biocenoses of the βm-zone the star duckweed, the Elodea canadensis, and the dark-green hornwort, and in the o-zone the autumn chickweed and the alternate-flowering water milfoil (Myriophyllum alterniflorum); the floating pondweed was mentioned in both cases.

In a book by Vipla (G. Whipple) et al (1927), a summary is presented on the saprobicity of individual indicator organisms. As to the higher plants, in particular, use was made of the studies of Kol'kvits and Marson (Marsson) (1908_1 and 1909_2), Kol'kvits (1911_3), Dzhonson (Johnson) (1914_4), Ol'myuller and Shpitta (Ohlmuller and Spitta) (1921_5). They listed: the dark-green hornwort $\beta m_{1,4}$, Elodea canadensis $\beta m_{1,3,4,5}$, the lake quillwort o_1, and the prickly hornwort (Jsoetes echinosporum) o_1, the small duckweed $\beta m_{1,4}$, the multirooted duckweed $\beta m_{1,3}$, and the star duckweed o_2, the yellow pond-lily βm_3, $o_{1,3}$, the white water lily βm_3, $o_{1,3}$, the common reed (Phragmites communis) αm_5, βm_5, o_5, the curly-leaved pondweed βm_5, $o_{1,3,5}$, the fennel-leaved pondweed $o_{1,4}$, and the streaked-leaved pondweed βm_1, o_3, and Salvinia natans o_1.

([NOTE] The numerical indices for the years of publication of these studies are presented below in a list of plants by

designations of saprobicity, indicating in each case the author of each interpretation.)

Except for one doubtful case (the common reed) (Ol'muyller and Shpitta, 1921), freshwater plants usually are not among the organisms serving as indicators of saprobicity. The higher macrophytes serve as indicators of saprobicity only within the limits of β-mesosaprobic and oligosaprobic zones, although they are found also under α-mesosaprobic zone conditions.

In the lists of saprobic organisms prepared by various authors we find contradictions, but as far as some plants are concerned though there be no total harmony of views, in each case the views are quite close.

Making a comparative analysis of the literature data on saprobicity and using some of the author's own observations and considerations, the author will here attempt to express himself on this problem.

The lake quillwort, and also probably, the prickly quillwort are completely determined oligosaprobes. There is greater reason to include Salvinia natans among the oligosaprobes than among the β-mesosaprobes. The same can be said also for the pond-lily and the water lily, although the yellow water lily has a tendency also to flourish under β-mesosaprobic conditions of habitation or closely related conditions. The bushy pondweed, the filaceous buttercup, and the spreading buttercup obviously are oligosaprobes, although the filaceous buttercup is not among the indicator organisms of Zhadin and Rodina (1950). These authors excluded wholly in order the floating pondweed from the list of saprobicity indicators. The small duckweed and the multirooted duckweed are β-mesosaprobes, but the star duckweed is a oligosaprobe and a β-mesosaprobe. Elodea canadensis and particularly the dark-green hornwort belongs among the β-mesosaprobes. Chickweeds are found in oligosaprobic and β-mesosaprobic zones. The fennel-leaved pondweed, the curly-leaved pondweed, the shiny pondweed, and the streaked-leaved pondweed are species found in the oligosaprobic and in the β-mesosaprobic zones, but the first two are characterized much the greater contamination than the last two. Thus, the author found in 1956 the streaked-leaved pondweed in the Moscow River near the city of Moscow; in contaminated sites of the river it is absent, appearing only below the city, where to some extent water purification is already underway -- by the Sof'inskiy Hydroelectric Station (Sysin and Litvinov, 1959). At contaminated and muddier sections of the Moscow River in 1956 the fennel-leaved pondweed was widespread. Still it was among the plants found in the contaminated water-drainage canal (at "Kanava") of Moscow. The fennel-leaved pondweed is one of the widespread plants both in the geographical sense, as well as ecologically. This pondweed is very polymorphous and, undoubtedly, is a composite species (Flora SSR /Flora of the USSR/, I, 1934). The streaked-leaved pondweed is also a widespread species.

The system of saprobicity calls for further revision, particularly in regard to increased contamination of industrial origin.

It is very important to take into account the external appearance of plants. Thus, at several sections of the contaminated part of the Pakhra River the air-exposed leaves of sturdy arrowhead plants had wide blades, but in the relatively pure Klyaz'minskiy Reservoir these blades were narrow, and the plants themselves were not as sturdy. It is possible to visually establish from macrophytes the sections of the Pakhra River differing in their sanitary-biological conditions.

Regionalizing the section of this river examined by species composition of plants and by how abundant each species is led to the separation of six sections with different degree of contamination.

The first section above the discharge of waste waters is marked by the largest number of species of higher plants. More sharply pronounced is the prevalence of the floating pondweed, the streaked-leaved pondweed, the shiny pondweed, and the arrowhead (Sagittaria sagittifolia). Absent are the Elodea and the dark-green hornwort. This section, not to be spoken of in general as pure, still is somewhat more favored than the adjoining section.

The second section, in length not less than 0.3 km, is situated directly below the site of waste water discharge into the river. Here the burweed (Sparganium) dominates, as well as the arrowhead and the dark-green hornwort. The arrowhead in this section and also in the subsequent third section is marked by vigorous plants and by the shape of the air-exposed leaves, which have relatively broader lobes to the blades than, for example, in the fifth section. Typical for this section is the good green color of the hornwort, which is brown in several other sections. The Elodea and the multirooted duckweed is found in this section. The role of submerged water plants, besides those indicated above, is of less importance here than in the preceding section. The origin within the limits of this section of yellow water lily is explained by the irregular effects of waste waters. It is the most contaminated section; within its limits mixing of waste waters with river water occurs.

The third section extends for ~1 km, under the influence of the periodic incursion of a large amount of mineral suspended matter (clayey). In this section, among the plants prevalent by location are noted those which were listed for the first section. The number of submerged water plants in this section is higher compared to the preceding. Found here for the first time has been the fennel-leaved pondweed, and also the small duckweed. The Elodea, the dark-green hornwort, the multirooted duckweed, and also the yellow water lily continue to be found here. In comparison with the second section the contamination is less.

The fourth section, not less than 3 km in length, is marked by increased depth and width of the water-occupied channel. In accordance with a drop in the current flowrate bottom accumulations also containing organic matter occur. Due to this there is secondary contamination. Among the dominating plants we note the arrowhead, the yellow water lily, and the dark-green hornwort. Increase in the numbers of water lily depends on how close the section is to conditions of a standing body of water. Secondary contamination, distinct in quality from primary, evidently does not impede the development here of this not unconditional oligosaprobe. The abovementioned three species of pondweed continue to be found dominating. There are indications of increased contamination of water compared to the previous section.

The fifth section is approximately 5 km from the place of waste water discharge into the Pakhra River. This section is free-dam and is characterized by being almost a standing body of water with still greater depth. Due to the impossibility of singling out the especially prevalent plants a list of the plants is presented here. They comprise the burweed, the streaked-leaved and fennel-leaved pondweeds, the arrowhead, the flowering rush (*Butomus umbellatus*), the lake rush (*Scirpus lacustris*), the rooted rush (*S. radicans*), the sedge (*Carex*), the water manna grass (*Glyceria aquatica*), the yellow water lily, and the dark-green hornwort. The water becomes pure.

The sixth section lying below the dam was traced for about 1 km. At first the section contains only moderate depth, and then sandbanks alternate with pools. Dominating among the plants (although not found everywhere in the section) is the lake rush, which nowhere above this section attains such a growth, and the water lily. Present are the streaked-leaved and the fennel-leaved pondweeds, and also the hornwort. In terms of water contamination this section in general is similar to the previous one.

Some macrophytes have proven to be good and observationally accessible indicators of displacement of bottom ooze deposits, as was stated also in the work of M. S. Yanshina (1949), who noted that this vegetation corresponds precisely to accumulations of bottom deposits.

The hydrobionts participating in the process of self-purification can serve as indicators of contamination of water and bodies of water.

The macrophytes have been established as participating in the self-purification of bodies of water (Kabanov, 1958), using the example of the fennel-leaved pondweed, at regulated and contaminated sections of the Moscow River. From sanitary-biological indices the water in thickets of this plant is purer than apart from such growth in the center of the river. One of the aspects of plants participating in self-purification of bodies of water from contamination is also their photosynthetic activity (Kabanov, 1961b).

Each geographic latitude has specific fluctuations in the biomass of water and mainly freshwater plants. Particular deviations from the usual biomass values can appear under different ecological conditions. Thus, increased biomass can emerge from the abundance of nutrients in water and bottom. In a contaminated section of the Moscow River near the village of Zaozer'ye the fennel-leaved pondweed biomass in 1956 amounted to 3.09 kg/m^2 in dry weight and 0.34 kg/m^2 in air-dried weight. In the Klyaz'minskiy Reservoir, where the water is considerably cleaner and less rich in biogenic elements, in 1948 the biomass of the fennel-leaved pondweed came to 0.60-0.65 kg/m^2 in dry weight, and 0.12-0.15 kg/m^2 in air-dried weight (Kabanov, 1959). In 1957 during the period when the waters of the Moscow River were purer than in 1956, the biomass of the fennel-leaved pondweed was less: near the village of Zaozer'ye the figure was 0.80 kg/m^2 in dry weight and 0.11 kg/m^2 in air-dried weight, and near the city of Bronnitsa -- 0.70 and 0.11 kg/m^2, respectively. Vigorous specimens of arrowhead were observed by the author in 1947 in a contaminated section of the Pakhra River below the city of Podol'sk, which also pointed to increased biomass (cf below).

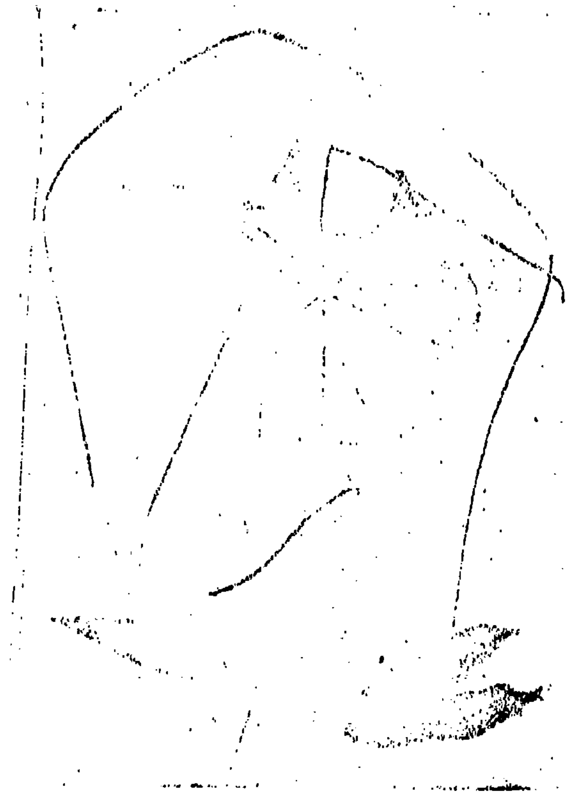
However, in very contaminated water macrophytes are suppressed almost to their total elimination. Also precluding growth of macrophytes in bodies of water are various toxic effects.

Biomass increase can also occur when the water temperature rises, which occurs in ponds or reservoirs near thermal electric power stations. For example, in the reservoir of the Gor'kavskaya GRES /Gosudarstvennaya Rayonnaya Elektrostantsiya; State Regional Electric Power Station/, which in 1930 was examined by the Okskaya Biological Station (Kabanov, 1934), a macrophyte study was made by K. V. Dobrokhotova, and in 1934 and 1937 this reservoir was examined by R. M. Pavlinova. Pavlinova (1939) determined the following biomass values for three plants: the broad-leaved cattail (Typha latifolia) -- 23.0 kg/m^2 in dry weight, and 11.50 kg/m^2 in dry weight with 12% moisture; Elodea canadensis -- 15.5 and 1.86 kg/m^2; dark-green hornwort (at a depth of 0.75-1.0 m) -- 14.3 and 1.70 kg/m^2. For comparison we can present data on the Klyaz'minskiy Reservoir (Kabanov, 1959, 1961a): broad-leaved cattail -- 9.0 kg/m^2 in dry weight and 1.84 kg/m^2 in air-dried weight; and Elodea canadensis -- 2.72 and 0.46 kg/m^2, respectively.

Thus, differences in plant biomass are substantial. Every change in normal temperature conditions in the bodies of water that are widely used, and especially, used for purposes of centralized water supply, can be considered as a disturbance from the sanitary-hygienic point of view.

The common reed is also one of our widespread plants (Flora SSSR, II, 1934). Its height, and consequently its biomass as well, increases from north to south.

In the Vorontsovo-Nikolayevskiy Reservoir in Sal'skiy Rayon, Rostovskaya Oblast, on 26 June 1949 at a distance of 50 meters from



Petroleum "Burns" of Upper Side of Floating Arrowhead Leaves

the dam in accordance with the latitude position of the locality the height of these plants came to 3.75 meters at a distance of 6 meters from the bank, and 3.8 meters -- at 8 meters from the bank. In the first case their biomass came to 6.32 kg/m^2 in dry weight and 3.66 kg/m^2 in air-dried weight, in the second -- 7.41 and 4.14 kg/m^2, respectively. In the pre-estuary section of the Rybasov channel, adjoining the reservoir, the reed came to 3.45 meters in height, and its biomass was 6.74 kg/m^2 in dry weight and 3.25 kg/m^2 in air-dried weight. However, in the lowest part of this same channel, where wastewaters from the city of Bel'sk were discharged, dwarfed and scattered thickets of reed were found, entirely like those described above. It can be assumed that here the effect of contamination entering into the supporting structure of the reservoir at the estuary portion of the Rybasov

As is known, heavy petroleum fractions leave traces at the water's surface along the shores, on various objects floating in bodies of water, and also on plants. S. M. Drachev (1951) proposed a scale of visual determination of petroleum contamination of bodies of water on a five-degree system. When an evaluation is given at degree 3, this signifies individual blotches along the banks and on the shore-line vegetation. Degree 4 denotes that the bank and the shore-line vegetation are covered over by petroleum. Degree 5 indicates that the shore and the shore-line structures are covered by petroleum; the plants are not referred to because it is assumed that they are absent under such an intense contamination by petroleum of the body of water, which actually has been observed.

The author noted on 22 August 1947 in the central section of one reservoir the effects that lighter petroleum fractions had on plants. Floating leaves of the arrowhead had "burns" on their upper side in the form of solid or blotched browning (cf figure). The damage to the upper side of the leaves is explained by the position of the film of the petroleum product on the surface of the water and by the concentration of the stomatal apertures on the upper side of the floating leaves. In a cross section of the leaf it could be clearly seen that tissue damage had spread from the upper side to the lower. Such "burns" have been observed on the leafy stems of the small duckweed and the multirooted duckweed, also floating at the surface of the water, which have their stoma at the upper side. The floating leaves of the arrowhead and the duckweed blades gave off the odor of kerosene in this case. Thus, the plants can also preserve traces of residence in a body of water of light fractions of petroleum as well.

LITERATURE

1. Dolgov, G. I., Nikitinskiy, Ya. Ya., 1927. "Hydrobiological Methods of Research," Standartnyye metody issledovaniya pit'yevykh i stochnykh vod /Standard Methods of Ivestigating Potable and Waste Waters/, Moscow.
2. Drachev, S. M., 1951. "The Klyaz'minskiy Reservoir as a Source of Potable Water Supply," Trudy akademii meditsinskikh nauk SSSR /Proceedings of the Academy of Medical Sciences USSR/, vol X.
3. Zhadin, V. I., Rodina, A. G., 1950. "Biological Foundations of Water Supply and Water Purification," Zhisn' presnykh vod SSSR /Life of Fresh Waters of the USSR/, vol III.
4. Kabanov, N. M., 1934. "Biological and Chemical Examination of the Impounded Waters of the Gor'kovskaya GRES on the Zhelesnitsa River," Yezhemesyachnik Gor'kovskogo krayevogo upravleniya yedinoy gidrometeorologicheskogo sluzhby SSSR /Monthly of the Gor'kovskiy Kray Administration of the Unified Hydrometeorological Service of the USSR/, No's 2-3.

5. Kabanov, N. M., 1958. "Macrophytes and Plankton of Regulated Bodies of Water," Tezisy dokladov nauchnoy konferentsii po voprosam gigiyeny vodokhranilishch 24-28 June 1958 g. Moskvy /Abstracts of Papers Presented at the Scientific Conference on Problems of Reservoir Hygiene on 24-28 June 1958 at Moscow/.
6. Kabanov, N. M., 1959. "Problems of Overgrowth in the Klyaz'minskiy Reservoir," Trudy vsesoyuznogo gidrobiologicheskogo obshchestva /Proceedings of the All-Union Hydrobiological Society/, vol IX.
7. Kabanov, N. M., 1961a. "Chemical and Sanitary-Biological Role of Macrophytes in the Klyaz'minskiy Reservoir," Ibid, vol XI.

10,123
CSO: 2645-S

- END -